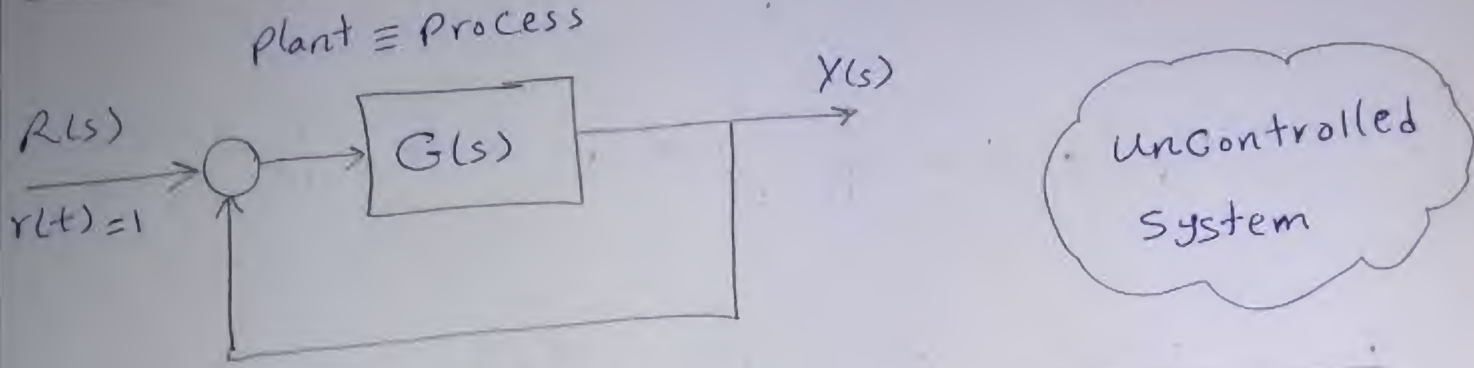
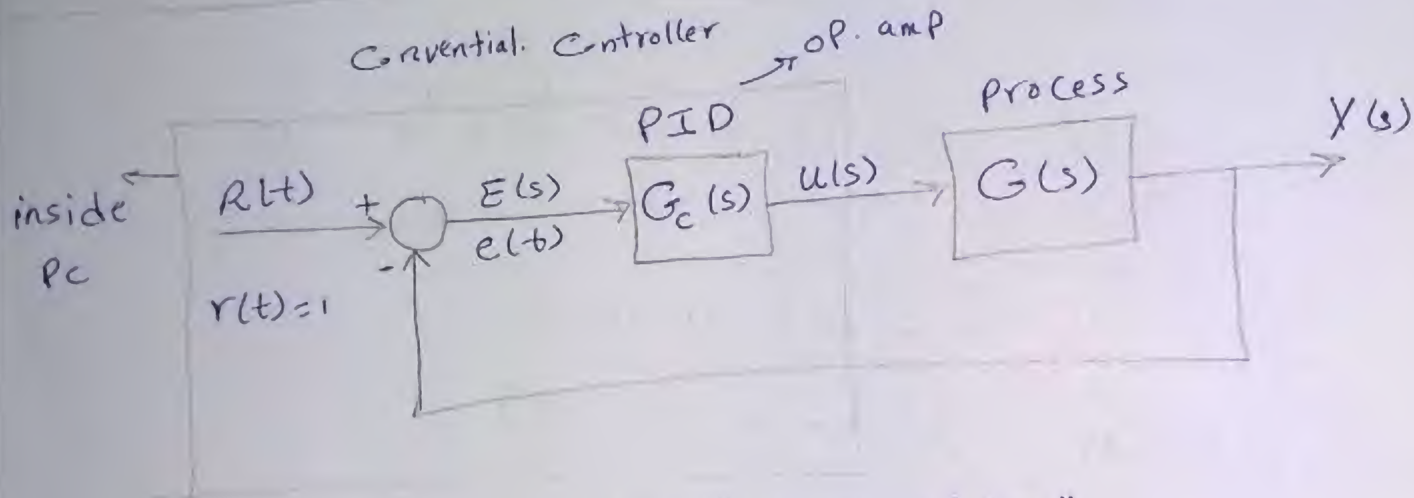
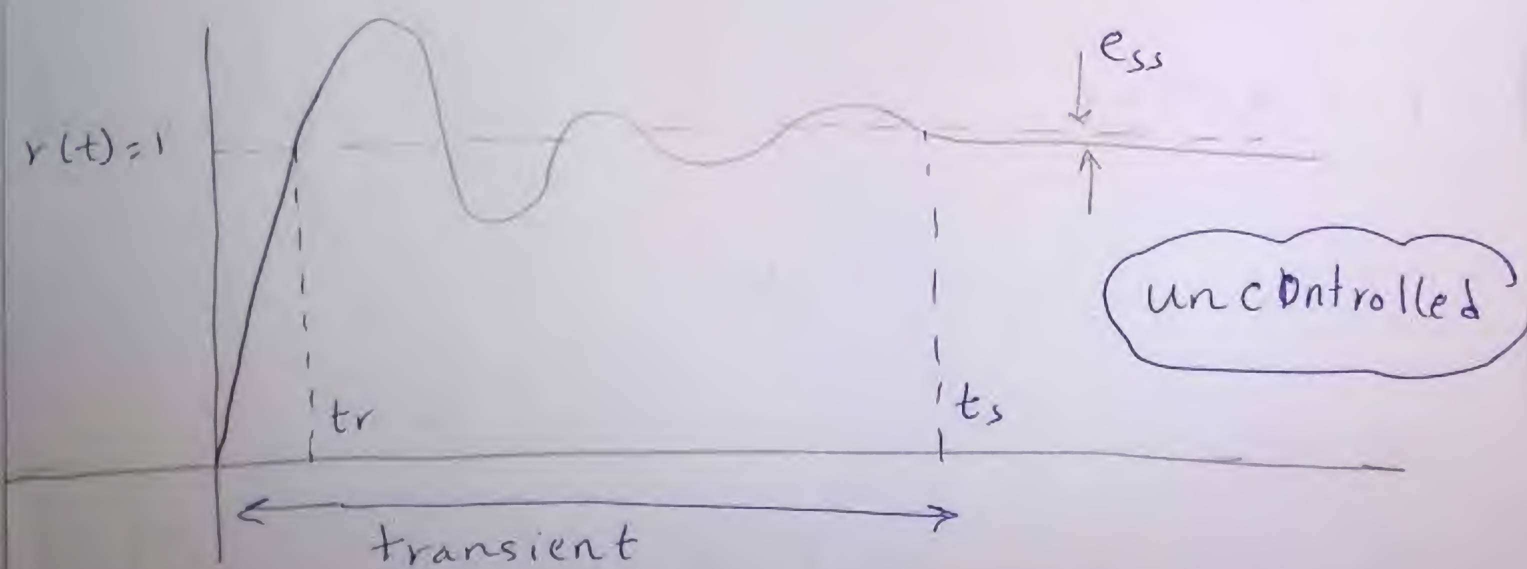
Lec 16

→ Design of PID Controller "Contin"





"Controlled system"



* in the controlled system :-

$$u(t) = K_p \cdot e(t) + K_i \int e(t) \cdot dt + K_d \frac{d}{dt} e(t)$$

$$= K_p \left[e(t) + \frac{1}{T_i} \int e(t) \cdot dt + T_d \frac{d}{dt} e(t) \right]$$

$$G_c(s) = \frac{U(s)}{E(s)} = K_p + \frac{K_i}{s} + K_d s$$

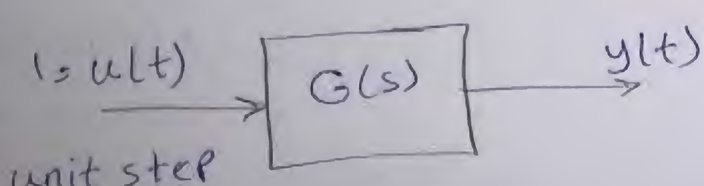
$$G_c(s) = \frac{U(s)}{E(s)} = K_p \left[1 + \frac{1}{T_i} \frac{1}{s} + T_d s \right]$$

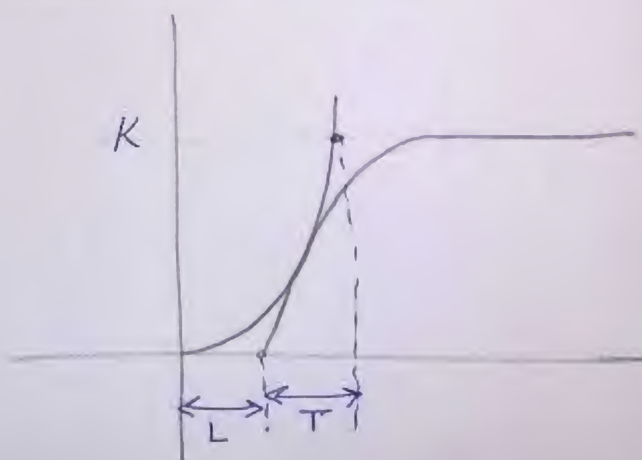
$\Rightarrow$ Trial error <<

$\Rightarrow$ ziegler - Nichols (Z-N)

$\rightarrow$ there are two methods for (Z-N)

1 st Method





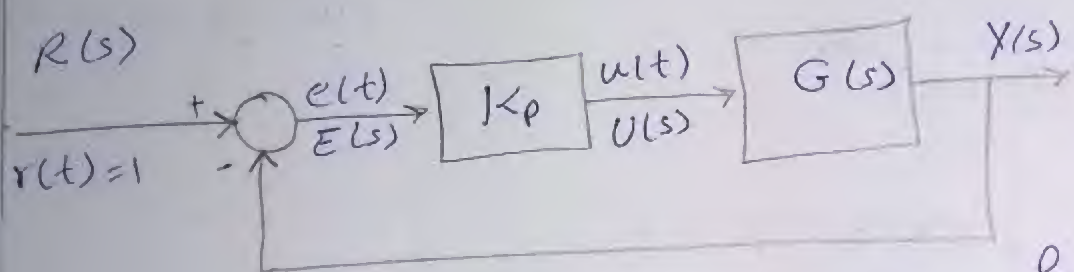
ـــ يساوي ثابت (K) ولا يساوي (1) لعدم وجود (Feedback).

ـــ المنحنى يسمى S-shaped.

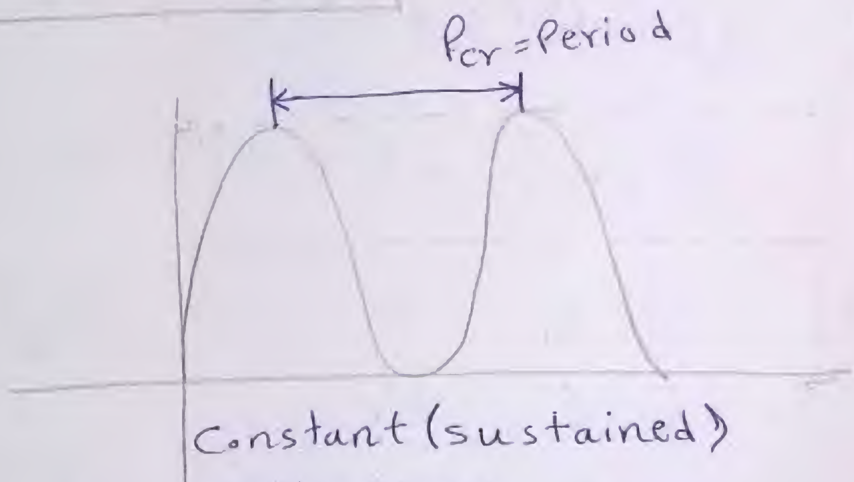
$$K_p = 1.2\left(\frac{T}{L}\right) \quad \& \quad T_i = 2L \quad \& \quad T_d = \frac{L}{2}$$

$$K_i = \frac{K_p}{T_i} = \frac{1.2\,T}{2L^2} \quad \& \quad K_d = T_d \cdot K_p = \frac{1.2}{2}(T)$$

* 2nd method



system is critically.



Constant (sustained) oscillations

K_{cr} ≡ critical gain

$$K_p = 0.6\,K_{cr}$$

$$T_i = \frac{P_{cr}}{2}$$

$$T_d = \frac{P_{cr}}{8}$$

$$K_p = 0.6\,K_{cr}$$

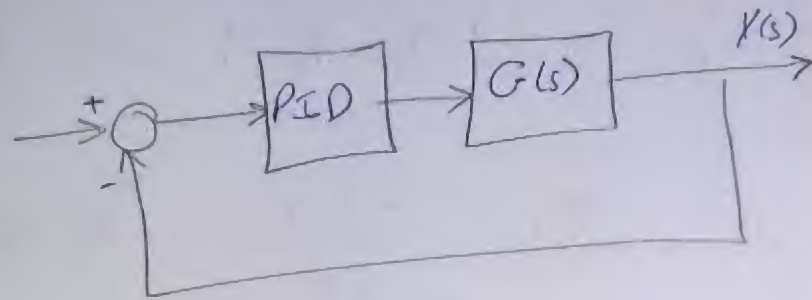
$$K_i = \frac{1.2\,K_{cr}}{P_{cr}} \qquad K_d = \frac{0.6}{8}\,K_{cr} \cdot P_{cr}$$

Routh stability criterion

* Routh array

EX

$$G(s) = \frac{1}{s(s+1)(s+5)}$$



Ch. eqn $= 1 + K_p\,(G(s)) = 0$

نضرب ف المقام

$$1 + \frac{K_p}{s(s+1)(s+5)} = 0$$

$$s(s+1)(s+5) + K_p = 0$$

$$s^3 + 6s^2 + 5s + K_p = 0$$

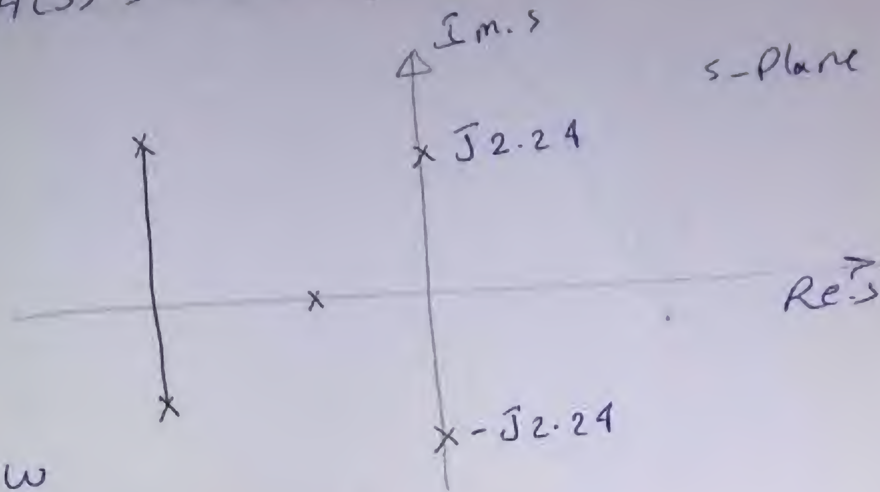
s^3	1	5
s^2	6	K_p
s^1	$\frac{30-K_p}{6}$	
s^0	K_p	

$$\frac{30-K_p}{6} = 0 \rightarrow \text{critically stable system}$$

$K_p = 30$ critical eqn

auxiliary eqn $\quad A(s) = 6s^2 + 30 = 0$

$$\boxed{\omega = 2\pi f = \frac{2\pi}{P_{cr}}}$$



$s^2 = -5$

$\therefore\ s = \pm J\sqrt{5} = \pm J\omega$

$\omega = \sqrt{5} = 2.24$ rad/sec

& $K_{cr} = 30$

$P_{cr} = \frac{2\pi}{\omega} = \frac{2\pi}{2.24} = 2.8$ sec

$K_p = 0.6\, K_{cr} = 0.6\,(30) = 18$

$T_i = \frac{P_{cr}}{2} = \frac{2.8}{2} = 1.4$ sec

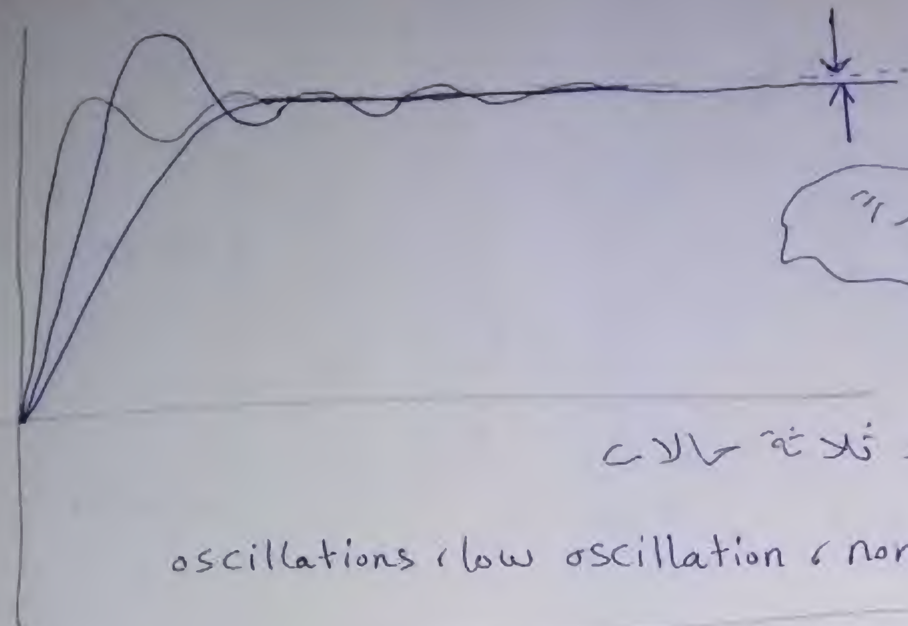
$T_d = \frac{P_{cr}}{8} = \frac{2.8}{8} = 0.35$ sec

$K_p = 18$

$K_i = \frac{K_p}{T_i} = \frac{18}{1.4} = ''$

$K_d = K_p \cdot T_d = 18\,(0.35) = ''$

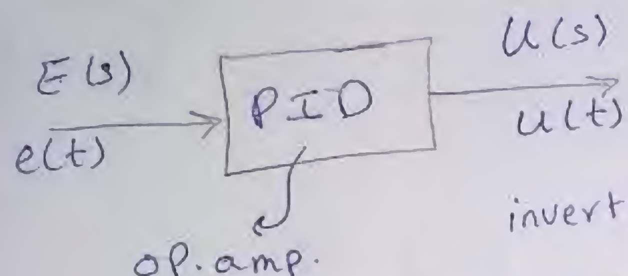
[5] Pa... 16

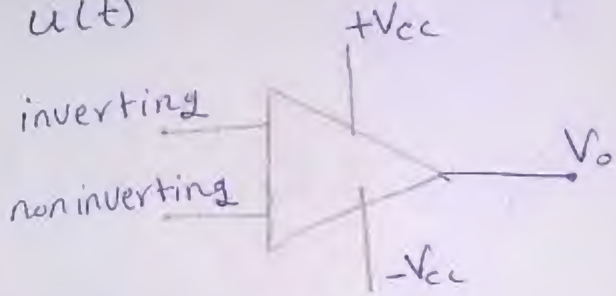


مسألة مهمة جداً
#إمتحان

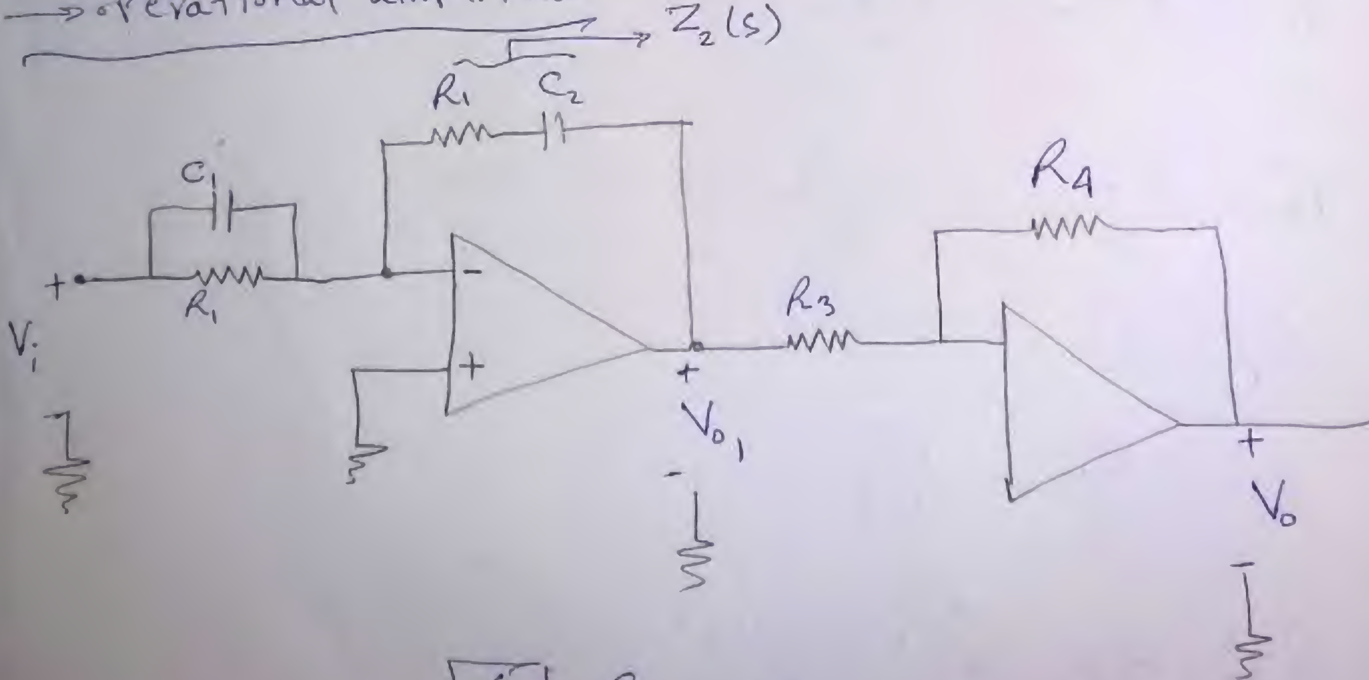
فلاحظ وجود ثلاثة حالات

oscillations ، low oscillation ، non oscillation





→ operational amplifier



$$\frac{U(s)}{E(s)} = K_P\left[1 + \frac{1}{T_i}\frac{1}{s} + T_d s\right] \Rightarrow *$$

$$\frac{V_o(s)}{V_i(s)} = \left(\frac{V_o(s)}{V_{o_1}(s)}\right)\left(\frac{V_{o_1}(s)}{V_i(s)}\right)$$

$$\frac{V_o(s)}{V_{o_1}(s)} = -\left(\frac{R_4}{R_3}\right) \quad \& \quad \frac{V_{o_1}(s)}{V_i(s)} = -\left(\frac{Z_2(s)}{Z_1(s)}\right)$$

$$\frac{V_o(s)}{V_i(s)} = \frac{R_4}{R_3} * \frac{Z_2(s)}{Z_1(s)}$$

$$* Z_1(s) = R_1 \,//\, \frac{1}{sC_1} = \frac{R_1/sC_1}{R_1 + \frac{1}{sC_1}} = \frac{R_1}{R_1 C_1 s + 1}$$

$$* Z_2(s) = R_2 + \frac{1}{sC_2} = \frac{R_2 C_2 s + 1}{sC_2}$$

$$\frac{V_o(s)}{V_i(s)} = \left(\frac{R_4}{R_3}\right)\left(\frac{R_2 C_2 s + 1}{sC_2}\right)\left(\frac{R_1 C_1 s + 1}{R_1}\right)$$

$$= \frac{R_4}{R_3} \cdot \frac{R_2}{R_1}\left[\frac{(R_2 C_2 s + 1)(R_1 C_1 s + 1)}{R_2 C_2 s}\right.$$

$$G_c(s) = \frac{V_o(s)}{V_i(s)} \cancel{\frac{R_4}{R_3}\,\frac{R_2}{R_1}\left[R_1C_1 + R_2C_2\right]}$$

$$= \frac{R_4}{R_3}\cdot\frac{R_2}{R_1}\cdot\left[\frac{R_1C_1+R_2C_2}{R_2C_2} + \frac{1}{R_2C_2s} + R_1C_1s\right]$$

$$= \frac{R_4}{R_3}\cdot\frac{R_2}{R_1}\left[1 + \frac{1}{(R_1C_1+R_2C_2)s} + \frac{R_1C_1R_2C_2}{R_1C_1+R_2C_2}s\right]$$

$$\boxed{G(s) = \frac{R_4\,(R_1C_1+R_2C_2)}{R_3R_1C_2}\left[1+\frac{1}{(R_1C_1+R_2C_2)s} + \frac{R_1C_1R_2C_2}{R_1C_1+R_2C_2}s\right]}$$

* *

بمقارنة * مع * *

$$K_p = \frac{R_4(R_1C_1+R_2C_2)}{R_3R_1C_2}$$

$$T_i = R_1C_1 + R_2C_2$$

$$T_d = \frac{R_1C_1R_2C_2}{R_1C_1+R_2C_2}$$

$$K_p = \frac{R_4}{R_3R_1C_2}(R_1C_1+R_2C_2)$$

$$K_i = \frac{K_p}{T_i} = \frac{R_4}{R_3R_1C_2}$$

$$K_d = K_p\cdot T_d = \frac{R_4R_2C_1}{R_3}$$